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Update on the Status of Striped Bass (*Morone saxatilis*) in eastern Canada in 1998

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ABSTRACT

Five self-sustaining populations of striped bass are known to have existed within Canadian waters. Four of these occurred in the Maritimes Region, with documented spawning activity on the Miramichi and Saint John rivers, New Brunswick, and the Shubenacadie and Annapolis rivers, Nova Scotia. The fifth population, now extirpated, spawned in the St. Lawrence River, Québec. Strong evidence indicates that of the original five populations only the Miramichi and Shubenacadie populations remain as viable representatives of this species at the northern limit of its natural spawning range. Miramichi and Shubenacadie fish are now the sole known representatives of the species within the Gulf of St. Lawrence and Bay of Fundy biogeographic regions respectively. There is no empirical evidence to support claims that self-sustaining populations of striped bass occur elsewhere in the southern Gulf of St. Lawrence, either along the mainland shore or in Prince Edward Island waters. Biological, ecological, and habitat factors contributing to uncertainty in striped bass management in the Maritimes region are discussed.

RÉSUMÉ

On sait que cinq populations autosuffisantes de bar rayé étaient présentes dans les eaux canadiennes. Quatre de celles-ci se trouvaient dans la région des Maritimes; on a établi qu'elles frayaient dans les rivières Miramichi et Saint-Jean, au Nouveau-Brunswick, ainsi que Shubenacadie et Annapolis, en Nouvelle-Écosse. Maintenant disparue, la cinquième population se reproduisait dans le fleuve Saint-Laurent, au Québec. Des indices sérieux indiquent que seuls les stocks de la Miramichi et de la Shubenacadie persistent en tant que populations viables de cette espèce à la limite nordique de son aire de reproduction naturelle. Les bars rayés de ces deux rivières sont maintenant les seuls représentants connus de l'espèce dans les régions biogéographiques du golfe du Saint-Laurent et de la baie de Fundy respectivement. Aucune indication empirique n'appuie les affirmations selon lesquelles des populations autosuffisantes de bars rayés seraient présentes ailleurs dans la partie sud du golfe du Saint-Laurent, soit le long de la côte continentale ou dans les eaux de l'Île-du-Prince-Édouard. Le document aborde les facteurs biologiques, écologiques et liés à l'habitat qui contribuent à l'incertitude entourant la gestion du bar rayé dans la région des Maritimes.

INTRODUCTION

The anadromous striped bass (*Morone saxatilis* Order Perciformes; Family Percichthyidae) has a natural range that extends from the Gulf of Mexico to the St. Lawrence River estuary (Scott and Scott 1988). The Chesapeake Bay region of the eastern United States is generally regarded to be the centre of the species distribution and the region of highest abundance. The historical distribution of striped bass spawning in Canadian waters includes rivers flowing to the Bay of Fundy, the southern Gulf of St. Lawrence, and the St. Lawrence River (Scott and Scott 1988). The southern Gulf of St. Lawrence (Fig. 1) represents the northern limit of spawning for the species (Bradford and Chaput 1997).

Annual stock assessments have been conducted since 1993 on the southern Gulf of St. Lawrence stock. Stock assessments have never been conducted on Bay of Fundy populations. The last stock status report for these populations was in 1995 (Jessop 1995).

The purposes of this study are to:

1. update the stock status of striped bass in eastern Canada,
2. identify common issues and concerns (biological, ecological, and habitat-related) contributing to uncertainty in the management of striped bass at the regional level,
3. recommend research activities that will provide guidance for striped bass management.

LIFE-HISTORY ATTRIBUTES IN CANADIAN WATERS

The native Canadian populations of striped bass share many common life-history attributes. Adults enter fresh to slightly brackish water to spawn during the vernal spring. The upstream migration occurs during May-June and rarely extends far above the head of tide (Adams 1873; Jessop 1990,1995; Rulifson and Dadswell 1995; Robichaud-LeBlanc et al. 1996; Tull 1997). The duration of the spawning run is brief. Spent fish usually return to sea within two weeks (Bradford and Chaput 1997). The onset of spawning occurs when the water warms to 15-18 ^{0}C (Williams et al. 1984; Robichaud-LeBlanc et al. 1996; Tull 1997). Eggs and milt are released directly into the water column. Fertilized eggs are slightly negatively buoyant in fresh water (Tull 1997; R. Bradford unpublished data) and tend to remain suspended in the water column during incubation, as a consequence of the effects of tidal stirring and dispersal into waters of higher salinity/density.

Free swimming, pelagic yolk-sac larvae hatch out after about 72 h (Robichaud-LeBlanc et al. 1996; Tull 1997). Yolk reserves are exhausted within about seven to 10 days after which the larvae forage on zooplankton within the estuary (Robichaud-LeBlanc et al. 1997). The transition from larva to juvenile occurs within about six weeks after which the young fish form schools and assume a more demersal mode of existence (Robichaud-LeBlanc et al. 1996, 1997). Adult and juvenile (age 1^{+} and older) striped bass may range several hundred kilometers beyond their natal rivers to forage during the summer and autumn months (Hogans and Melvin 1984; Rulifson et al. 1987; Bradford et al. 1995a; Bradford and Chaput 1996). Studies on southern Gulf striped bass show that males reach maturity at about age three whereas females generally spawn for the first time at age four (Bradford and Chaput 1996).

Northern striped bass return to estuarial/freshwater habitats at the onset of winter conditions (Hogans and Melvin 1984; Hanson and Courtenay 1995; Rulifson and Dadswell 1995; Bradford and Chaput 1996). Southern Gulf striped bass do so presumably to avoid low lethal marine temperatures (<-0.7°C). Site selection for overwintering appears to be opportunistic, and largely dependent on the geographic location of fish at the onset of winter (Bradford and Chaput 1996). A return to the estuary of previous spawning before winter is not necessary for repeat spawning in that same estuary the following spring (Bradford et al. 1995a; Bradford and Chaput 1996).

Striped bass which enter their first winter at a fork length <10 cm have been shown to be less likely to survive the winter than those which are >10cm (Bernier 1996; Bradford and Chaput 1997). Mortality has been linked to size-dependency of both starvation endurance and resistance to osmotic stress at low temperatures (Hurst and Conover 1998). Variability among years in the average pre-winter lengths of young bass combined with differences in spawner success can profoundly affect recruitment in these northern populations.

SPAWNING POPULATIONS IN CANADIAN WATERS

Documented Self-Sustaining Populations

Evidence, in the form of confirmed occurences of eggs/larvae, age 0+ juveniles, and ripe and running adult fish, lends certainty to claims of an historical spawning distribution that included at least five eastern Canadian rivers (Table 1). These are (Fig. 1):

Québec

- St. Lawrence River, Québec (Rulifson and Dadswell 1995)

Maritme Provinces

- Northwest Miramichi River, New Brunswick (Bradford et al. 1995a; Robichaud-LeBlanc et al. 1996)
- Saint John River, New Brunswick (Jessop 1995)
- Shubenacadie-Stewiacke River, Nova Scotia (Tull 1997; Paramore 1998)
- Annapolis River, Nova Scotia (Williams et al. 1984)

Inferred/Suspected Populations

- Mainland estuaries, southern Gulf

The number of self-sustaining spawning populations of striped bass within the southern Gulf of St. Lawrence has long been a subject of inference and conjecture. Circumstantial evidence suggests that spawning occurs -or once occurred- in as many as five rivers (Table 1) in the southern Gulf other than the Miramichi River; the Nepisiguit, Tabusintac, Kouchibouguac, Richibucto and Buctouche rivers (Fig. 1) (Wirgin et al 1993; Rulifson and Dadswell 1995). Adult striped bass occur, with interannual predictability, within these estuaries from the time of ice-out (late March-early April) to early spring (mid-May)(LeBlanc and Chaput 1991; Bradford and Chaput 1996). Sporadic reports of occurrences of age 0^{+} and older juveniles in these estuaries (Hogans and Melvin 1984; Madden 1984; Bujold 1985; Robinson et al. 1998), has supported the view that spawning is possibly wide-spread throughout the southern Gulf of St. Lawrence in some years. Juvenile striped bass are assumed to remain within or near their natal river until about age 2 (Hogans and Melvin 1984; Wirgin et al. 1993) as appears to be the case for populations occurring along the eastern seaboard of the U.S. A. (Waldman et al. 1990).

Mark-recapture studies have contradicted this view (Bradford et al. 1995a; Bradford and Chaput 1996, 1997) and instead indicate that southern Gulf striped bass comprise a single stock that spawns in the Northwest (NW) Miramichi River estuary (Bradford et al. 1995a; Bradford and Chaput 1996, 1997, Bradford et al.1998). The spawning run on the Miramichi is brief, usually lasting from the last week of May to the second week of June in recent years ((Robichaud-LeBlanc et al. 1996; Bradford et al. 1998). For the remainder of the year, including the period from ice-out to mid-May, NW Miramichi striped bass are broadly distributed throughout the southern Gulf (Bradford et al. 1995a; Bradford and Chaput 1996, 1997). Their known natural range extends from Percé, Québec to Margaree, Cape Breton (Bradford and Chaput 1996). Occurrences of early spring concentrations of striped bass within individual estuaries are likely reflections of the winter distribution of Miramichi-spawning fish as opposed to an indicator of localized spawning activity.

- Prince Edward Island, southern Gulf

Most accounts of early settlement on PEI do not include striped bass in lists of fishery resources, although a few give it passing mention (Harvey 1955, Clark 1959, Gallant and Arsenault 1980, Wells

1986, Cairns 1997). The most detailed early account of PEI fisheries was by John Stewart, whose report was originally published in 1806 (Stewart 1967). Stewart referred to "bass" with the scientific name *Perca ocelata*, which, he said, were "in great numbers in all our harbours." He noted that bass were commonly taken at night with a hook and line at the entrances to north shore harbours, and speared on flats, bays, and harbours of the south side, where "they are in great plenty." Bass were taken in the course of night-time eel spearing from boats equipped with birchbark torches, a fishery which occurred in the summer months.

At the present time bass are occasionally encountered in Prince Edward Island rivers, including the Hillsborough, Dunk, and Morell, most often as bycatch in the gaspereau fishery. The most frequent catches appear to be in the Hillsborough River, which is the source of most broodstock used in culture experiments at the Cardigan Fish Hatchery (Cairns et al. 1999). These fish were in an advanced reproductive state at their time of capture, were spawned successfully in captivity shortly after transfer to the hatchery (R. Angus, Hatchery Manager, Cardigan Fish Hatchery, personal communication), and yielded viable eggs and larvae.

On 9-10 September 1998, 12 sites on the Hillsborough were fished by beach seine to search for juvenile bass, using 50 m sweeps (Fig. 2). Presence of juvenile bass would suggest that a spawning population might exist in the Hillsborough, as 0+ bass were captured by beach seining in the Miramichi and Shubenacadie Rivers during the same general period (R.G. Bradford and K. Robichaud-LeBlanc, unpublished data). No striped bass of any age were captured in the Hillsborough seining.

The absence of striped bass in the seine catches lends support to the notion that the species does not spawn in the Hillsborough, and that the bass found there have an external origin, most likely the Miramichi. However, the possibility that small numbers of striped bass spawn in the Hillsborough or other PEI rivers cannot be precluded on the basis of present data.

STATUS OF SPAWNING POPULATIONS IN CANADIAN WATERS

Extirpated

- St. Lawrence River, Québec

  The last reported commercial capture of striped bass from the St. Lawrence estuary occurred in 1965 (Trépanier and Robitaille1995). Reported occurrences thereafter have been infrequent. The fish are thought to be migrants from elsewhere (Trépanier and Robitaille1995).

- Saint John River, New Brunswick

  There has been no positive evidence of successful spawning by striped bass on the Saint John River system since 1979 (M.J. Dadswell, DFO memorandum, 2 February 1982). Surveys were unsuccessful in collecting either eggs or larvae or juveniles during either 1992 or 1994 (Jessop 1995). Adult striped bass still occur within the Saint John River system. Analyses of mitochondrial DNA indicate these are most likely seasonal migrants, with up to 80% having US river origins and the remainder being of Shubenacadie River origin (Wirgin et al. 1995).

Likely Extirpated

- Annapolis River, Nova Scotia

  Viable spawning by striped bass on this system has evidently not occurred since 1976 (Williams et al. 1984; Jessop 1990, 1995). Survival beyond the egg stage has been very low or negligible (Jessop 1990). A remnant population of old (>20 years of age) adult fish may still exist, owing to the general longevity (>25 years) of striped bass (Scott and Scott 1988).

Extant

- Northwest Miramichi River, New Brunswick

Striped bass likely comprise a single biological unit within the southern Gulf of St. Lawrence (Bradford and Chaput 1996). These Miramichi-spawning fish have a known summer range that extends from Percé, Québec to Margaree, Cape Breton Island (Bradford and Chaput 1996). The population has been at a reduced/declining level of abundance since 1992 with no prospects for a substantive recovery until 2001 at the earliest (Bradford and Chaput 1998). Spawner abundance in 1998, estimated at 3400 fish (575 females), is below the provisional conservation requirement of 5000 female spawners (Bradford et al. 1998).

- Shubenacadie-Stewiacke River, Nova Scotia

  Striped bass continue to spawn successfully on the Shubenacadie-Stewiacke River system (Jessop 1995; Paramore 1998; this manuscript). Their status relative to conservation requirements is unknown. The first stock assessment is planned for spring, 1999.

Concluding Remarks

There are currently only two sites within eastern Canada where striped bass are known to reproduce annually, the Northwest Miramichi River Estuary, southern Gulf of St. Lawrence, and the Shubenacadie-Stewiacke River Estuary, inner Bay of Fundy (Table 1). The two populations are genetically discrete and both differ genetically from the Hudson River and Chesapeake Bay stocks (Wirgin et al. ,993).

FACTORS CONTRIBUTING TO EXTIRPATION

- St. Lawrence River, Québec

  Extirpation has been attributed to a myriad of factors, including loss or excessive disturbance of spawning and overwintering habitat, poaching, and commercial overfishing (Robitaille and Ouellet 1990). Insufficient data is available to rank any of these factors by their relative contribution to the extirpation of the population.

- Saint John River, New Brunswick

  Habitat degradation and loss is believed largely responsible for the marginalization/extinction of the native stock of striped bass. Construction of the large Mactaquac hydroelectric impoundment on and upstream of the spawning grounds is believed to be the single greatest factor contributing to the cessation of spawning (Jessop 1995) including the unnatural fluctuations in water velocity and volume spilled from the dam. Jessop (1995) concluded that a reclamation of the spawning habitat lost when the Mactaquac Dam was built may be impossible. Dadswell (1976) attributed the high incidence of membrane rupture and embryo mortality to high levels of organochlorines (DDT, PCB). High PCB levels may have little effect on striped bass reproduction (ASMFC 1990).

- Annapolis River, Nova Scotia

  Jessop (1990) noted that "Eggs spawned in the Annapolis River are viable and have a high hatching rate when held in water of suitable quality from sources other than the Annapolis River." The failure of naturally spawned eggs to yield viable offspring and age 0^{+} striped bass in the river system suggests either inadequate water chemistry or quality (Jessop 1995) or perhaps deleterious alterations to the physical circulation of the estuary. The Annapolis River and estuary are impacted by tidal power development, natural pH depression, and agricultural runoff.

Concluding Remarks

Losses of self-sustaining populations of striped bass in Canadian waters appear to have been more strongly associated with disruptions and permanent alterations to essential habitat than with overexploitation through directed fishing or incidental catch. The southern Gulf of St. Lawrence population, for example, has persisted in spite of persistent high mortality from unregulated fishing over many

decades (fisheries succeeded in removing as much as 80% of the spawning stock between June, 1994 and March, 1996; Bradford and Chaput 1998). This level of exploitation greatly exceeds any established reference points for striped bass management. The target fishing mortality of striped bass in the eastern United States has been set at F =0.31 (annual removal of 27% of the stock) and the threshold F =0.40 (annual removal of 33%) (Northeast Fisheries Science Center 1998).

Striped bass appear to be highly intolerant of alterations to spawning, rearing and overwintering habitat. 'Environmental problems' appear to have caused the extirpations of striped bass from the St. Lawrence River, the Saint John River, and likely the Annapolis River.

The supporting habitat for the extant eastern Canadian striped bass populations of the Miramichi and Shubenacadie rivers continues to be at risk of alteration from land- and sea-based human activities. Terms of reference for environmental impact appraisals have yet to include possible impacts on striped bass.

MANAGEMENT CONSIDERATIONS

Two of the three known extirpations of striped bass from Canadian waters have occurred within the Maritimes region. Whether or not these extirpations represent an overall significant loss of genetic diversity is not known because the genetic relatedness of the five stocks known to have existed was never resolved. The overall loss in production of striped bass in Canadian waters from extirpation of three-fifths of the known populations is not known because abundance estimates have been (recently) obtained for only one stock (Miramichi) on an annual basis.

Until demonstrated empirically to be otherwise, striped bass management at the regional level should proceed on the basis that there are now only two self-sustaining populations of striped bass. The continued existence of this species at the northern limit of its natural spawning range now depends upon the viability of the genetically discrete Miramichi and Shubenacadie stocks.

Miramichi Striped Bass

The conservation requirements of the Miramichi population have been investigated since 1993. Stock status reports have been prepared on an annual basis since 1995. Sufficient information is now on hand to assist in the:

- control of bycatch in commercial fisheries
- allocation of striped bass to the First Nations for food, social, and ceremonial purposes, and
- control of striped bass bycatch in First Nation fisheries for other species.

The known home range of the Miramichi-spawning population extends through the entire southern Gulf of St. Lawrence and this should be recognized by fishery management actions. There are currently no regulations to control recreational striped bass angling in the Province of Québec (specifically the Chaleur Bay region of Gaspé). The 1998 Angling Regulations for the Province of Prince Edward Island included a daily bag limit and possession limit of striped bass of ten fish. Angling activity in the New Brunswick and Nova Scotia portions of the southern Gulf of St. Lawrence is on a hook-and-release basis only.

Protocols for determining the spawning-site affinity of striped bass where they occur in significant numbers anywhere in the southern Gulf have been established (Bradford et al. 1998). Any disagreement with the management of southern Gulf striped bass as a single biological unit can be resolved through simple extension of the current mark-recapture based stock assessment protocols.

Sufficient information has been acquired about the spawning, rearing and habitat requirements of Miramichi striped bass to require its use in environmental impact appraisals for industrial and domestic activites on land and sea throughout the southern Gulf region.

Shubenacadie Striped Bass

The conservation requirements of the Shubenacadie population are not known. Stock assessments have not been conducted on this population. There is minimal information on which to provide advice regarding the consequences of striped bass bycatch in commercial fisheries, or to estimate harvestable surplus either for First Nation uses or for management of the recreational angling fishery. In any case, retention of striped bass in commercial fisheries has been prohibited with the exception that up to three striped bass that exceed 68 cm in total length may be retained per day for personal use by licensed shad gillnet fishermen and one striped bass per day may be retained by weir or trapnet fishermen in the inner Bay of Fundy. The angling fishery is restricted to the retention of one fish exceeding 68 cm in total length per day. The home range of the Shubenacadie spawning population is virtually unknown but likely extends beyond the Bay of Fundy and Gulf of Maine to the northeastern portion of the U.S. Atlantic coast (e.g. see Rulifson et al. 1987). Current levels of exploitation in Canadian and US waters cannot be determined.

The spawning, rearing and habitat requirements of Shubenacadie striped bass have not been fully resolved. Descriptive studies (Tull 1997; Paramore 1998) indicate the population exhibits adaptations to the highly tidally energetic character of the estuary.

RESEARCH RECOMMENDATIONS FOR 1999

Resolve stock status of striped bass on Prince Edward Island (May, 1999-June, 2000)
In collaboration with client groups;
1)Mark-recapture experiments and biological sampling of adult and sub-adult striped bass captured in the Hillsborough River (May-June, 1999).
2)Search for recaptures of striped bass among the bycatch from Hillsborough River boxnet gaspereau fishery (May-June 2000).
3)Systematic beach seine surveys of Hillsborough River to establish presence/absence of young-of-the-year (July-October, 1999).
4)Establish linkages with southern Gulf of St. Lawrence striped bass program. Search for recaptures on the NW Miramichi of striped bass marked and released on the Hillsborough River (May-June, 1999, 2000).

Stock assessment of Shubenacadie River striped bass (May-November, 1999)
1)Mark adult and age 2^{+} juvenile striped bass during spring April-May downstream migration from Shubenacadie Lake.
2)Recapture striped bass during a) the downstream migration to estimate size of the wintering adult and juvenile populations, and b) as spawning adults captured incidentally in the April-June drift gillnet fisheries for gaspereau and American shad on the Stewiacke-Shubenacadie estuary to estimate spawner abundance.
3)Systematic beach seine survey of Shubenacadie estuary to collect young-of-the-year striped bass for growth studies and possible development of indices of spawner success.
4)Continue collections of pre-winter young-of-the-year striped bass for studies on winter mortality and recruitment.

Nictaux River hydroelectric generation and pH depression on the Annapolis River
1)Monitor pH (and labile aluminium) on the Annapolis River at three sites; upstream of confluence with Nictaux River, at the confluence, and downstream of the confluence on the spawning grounds.

Dynamics of water drawdown at Mactaquac and impact on spawning habitat
1)acquire and analyze data on seasonal discharge and temperature of river flows prior to construction of the Mactaquac Dam as compared with after dam construction.

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Table 1. Summary of documented and inferred/suspected spawning populations of striped bass in eastern Canada and their present status (extirpated =no longer exists, likely extirpated =no detectable successful spawning activity, extant = known to reproduce successfully; not supported =repeated efforts to document spawning activity have failed; data deficient =only cursory information available)

Spawning Population	Region	River Estuary, Province	Status
Documented	Laurentian	St. Lawrence, PQ	Extirpated
	Gulf	Miramichi, N.B.	Extant
	Scotia-Fundy	Saint John, N.B.	Extirpated
		Annapolis, N.S.	Likely Extirpated
		Shubenacadie-Stewiacke, N.S.	Extant
Inferred/Suspected	Gulf	Nepisiguit, N.B.	Not Supported
		Tabusintac, N.B.	Not Supported
		Kouchibouguac, N.B.	Not Supported
		Richibucto, N.B.	Not Supported
		Buctouche, N.B.	Not Supported
		Hillsborough, P.E.I.	Data Deficient

Figure 1. The Maritime Provinces, showing rivers used by striped bass.

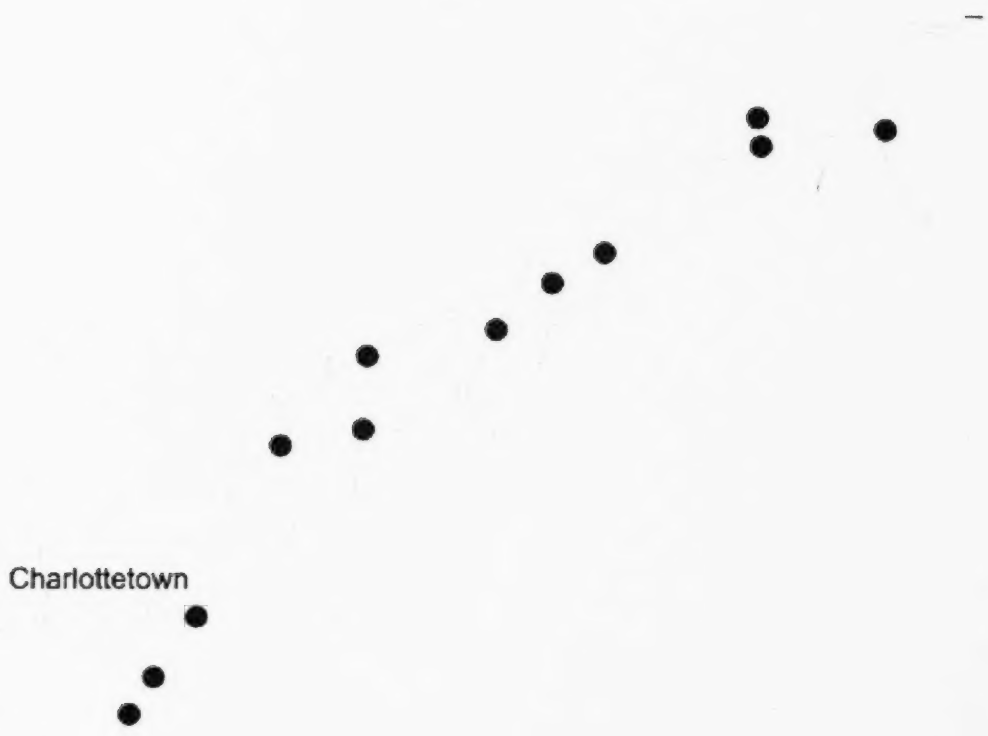

Fig. 2
The Hillsborough River, PEI, showing locations where beach seining was conducted on 9-10 September 1998.